Claims

1. **Method to protect objects, particularly buildings, against dynamic forces from accelerations of the base (6)**, e.g. caused by earthquakes, where in a load bearing system supporting the object (1) the effects of stable supporting elements (2, 11), able to swing in any lateral direction and lifting the mass of the object (1), and of unstable supporting elements (7, 11, 14), able to swing in any lateral direction and lowering the mass of the object (1), are superimposed through a coupling of the supporting elements (2,7,11,14) in such a way, that, during the oscillating horizontal earthquake movements of the base (6), the displacement of the base-connected support points (10) of the supporting elements (2, 7, 11, 14), relative to the position of the inert mass of the supported object (1), causes only a minimal lift of the supported object (1) on the load bearing support points (P) on the coupling elements or combined coupling-supporting elements, which in turn, because of the low gradient of the paths of movement in space relative to the base of the support points (P), generates only a small stabilizing returning force (F_R) to the center position caused by the gravity subjected mass of the object (1), which consequently results even during great lateral accelerations of the base in an only insignificant acceleration of the supported object (1) with a long period of its natural oscillation. (FIG.9, 12, 13, 16, 17, 21, 22, 23, 24)

2. **Device realizing the method according to claim 1 for the protection of an object (1), particularly of a building, against oscillations of the base (6), thus characterized** that, for the oscillation-discoupled bearing of an object (1) on its static load bearing support points (P) towards an oscillating base (6), the object (1) is supported on each device by a support point (P) on a coupling element or combined coupling-supporting element (8, 9, 14), that is supported and connected towards the oscillating base (6) by supporting elements (2, 7, 11) which are able to swing in any direction and which are coupled together by the coupling element or combined coupling-supporting element (8, 9, 14), and thus charcterized that the dimensioning and positioning of the supporting elements (2, 7, 11, 14) in their initial resting position is chosen in such a way, that on each coupling element or combined coupling-supporting element (8, 9, 14) the support point (P) for the supported object (1) is able to freely move in any lateral direction, comparable to the path of movement in the locus of a concave sphere in which the free end of a bi-axially suspended very long pendulum would move, realizing in effect a **Virtual Pendulum** that is able to swing in all directions. (FIG.9, 12, 13, 16, 17, 21, 22, 23, 24)

3. **Device according to claim 2, thus characterized** that during a horizontal amplitude of the oscillating base (6) the coupling element (8, 9, 14) is elevated at one side where it is linked to the supporting elements (2, 7, 11) and is lowered at the opposite side, and that the support point (P) on the coupling element (8, 9, 14) supporting the object (1) experiences only a minimal lift and moves in such a way as describing a flatly curved concave locus, seen from above. (FIG.9, 12, 13, 16, 17, 21)

4. **Device according to claims 2 or 3, thus characterized** that there are two supporting elements (2, 7) bi-axially hinged to one coupling element (8, 8b), where one of the two supporting elements (2) is realized as a hanging stable pendulum, that at its upper end is bi-axially hinged to a support point (10), which is rigidly connected to the base (6), and where the other of the two supporting elements (7) is realized as a standing unstable pendulum, that is bi-axially hinged at its lower end to the base (6), and where the coupling element (8, 8b) is connected to the supported object (1) through two bearings, creating a horizontal axis, so that, relative to the object (1), the coupling element (8) is prevented to rotate around its vertical axis. (FIG.9, 12, 13, 16, 17)

5. **Device according to claim 4, thus characterized**, that the coupling element (8) is articulated into an additional coupling element (8b), connected by a vertical coupling element (8a), at its both ends one-axially hinged to both coupling elements (8, 8b), and that the coupling element (8b), which is one-axially hinged to the load support (W_l) at one end and at its other is supported by the top of the unstable pendulum, supporting element (7), bi-axially jointed. (FIG.13 to 17)

6. **Device according to claims 2 or 3, thus characterized** that three supporting elements (11) are bi-axially hinged to three points along the perimeter of the coupling element (9, 14), each, when positioned in the resting position, pointing upwards and inclined away from the center of the coupling element (9), and each bi-axially hinged to suspension points, which are rigidly connected to the base (6). (FIG.18, 19)

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7. **Device according to claim 6, thus characterized** that the support point (P) for the object (1) is positioned above the plane formed by the three bearing points (12) on the coupling element (9) for the supporting elements (11). (FIG.19, 20, 21)

8. **Device according to claim 2, thus characterized** that the coupling element (8), bi-axially joined with at least two parallel support elements (2) at their lower end, which at their upper end are bi-axially joined with support points (10) that are rigidly connected with the base (6), supports in a one-axial bearing in its middle a support element (14), that tilts in the direction of the supporting points, which connect the coupling element (8) and the supporting elements (2), and that below its bearing in the coupling element (8) is positioneded in a bi-axial bearing with axially movability and above its bearing in the coupling element (8) supports the object (1) in a bi-axially movable support point (P).
(FIG.22, 23, 24)

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9. **Device according to claims 2 and 8, thus characterized**, that, differing from the device according to claim 8, the coupling element (8) is supported by several symetrically positioned parallel supporting elements (2), and the supporting element (14) is supported in the coupling element (8) in a bi-axial bearing. (FIG.22, 23, 24)

10. **Device according to claims 2 to 9 thus characterized** that, for the purpose of wind load compensation, a shaft (42) is positioned beneath the supported object (1) between the base (6) and the object (1) to restrain lateral forces, whereby one end of the shaft (42) is rigidly connected to one end of a preloaded extension spring (41), which other end is rigidly connected either to the base (6) or the supported object (1), and whereby the other end of the shaft (42) sticks axially movable into a bi-axially movable spherical bearing (43) that is connected either to the supported object (1) or to the base (6), and through which the position of the object (1) and the base (6) towards each other is fixed, and through which a relative movability of the base (6) and the object (1) towards each other becomes possible when a lateral force impacts the shaft (42) that exceeds the tension force of the preloaded extension spring (41). (FIG.25)

11. **Device according to claims 2 to 9, thus characterized** that underneath the supported object (1) between the base (6) and the object (1) is positioned a shaft to retain lateral forces, whereby one end of the shaft is rigidly connected to an elastomeric spring block (48), that is rigidly connected either to the base (6) or to the supported object (1), and whereby the other end of the shaft sticks axially movable into a bi-axially movable spherical bearing (43), which is connected either to the supported object (1) or to the base (6), through which the position of object (1) and base (6) towards each other is elastically fixed. (FIG.26)

12. **Device according to claims 2 to 9, thus characterized** that for the purpose of the compensation of wind loads underneath the supported object (1) one or several wind load compensation devices (50) are installed, whereby for each device a vertically guided sphere (44), that can turn in all directions, is pressed with a predetermined force by a mechanical or hydropneumatic spring (47) downwards into the center of a hollow cone (45), rigidly connected with the base (6), which has a particular opening angle that increases from its center to 180° degrees, through which a shape locked connection between the object (1) and the base (6) comes about, that can transfer horizontal forces up to a limit value, determined by the spring force and the opening angle in the center of the hollow cone (45). When the limit value is exceeded by the horizontal force, the incline of the hollow cone (45) lifts the sphere (44) vertically against the spring force, and the sphere (44) rolls into the area of the lessening incline of the hollow cone (45), through which the horizontally transferable force decreases and becomes zero outside the area of the hollow cone (45), and therefore, during relative movements of the base (6) towards and the object (51) caused by earthquakes, only little or, depending on the amplitude of oscillations, virtually zero horizontal forces are transferred from the base (6) onto the object. (FIG.27)

13. **Device according to claim 12** to center a, because of the kind of its support, horizontally easily movable object or building and to provide a retaining force, **thus characterized**, that a vertically guided centering sphere (44), held in a dish with rolling balls (49), is pushed by a mechanical or hydropneumatic or visco elastic spring into a centering hollow cone (45), so that no horizontal wind force impacting the building structure (51) can cause a reaction force at the connecting point of the centering ball (44) with the hollow cone (45), which vertical component (F_v) could push the centering ball (44) up in its vertical guidance against the spring force. (FIG.27)

14. **Device according to claim 12, thus characterized** that a centering hollow cone (45), outside of the circle that is formed by the contact line of the centering sphere (44) with the hollow cone in its lowest position within, has an up to 180° increasing opening angle (γ), so that the horizontal component (F_H) of the normal force in the contact point of the centering sphere (44) with the centering cone (45) decreases radially outward, when a lateral displacement force, which is greater than maximum horizontal wind loads, compresses through the centering sphere (44) the vertical spring in its vertical guidance, and the contact point of the centering sphere (44) and the centering cone (45) moves radially outward in the centering cone (45). (FIG.27)

15. **Device according to claim 12, thus characterized** that the centering sphere (44) in its vertical guidance can move undampened, if a vertical force (F_v), caused by a horizontal displacement of the centering hollow cone (45), exceeds the spring force, and that a pushing back of the vertical guidance with the centering sphere (44) by the spring is slowed to a very low speed by a hydraulic throttling, so that the time period for the full spring return is a multiple of a maximum earthquake oscillation time period. (FIG.27)

Sub 92 **16.** **Device according to claims 2 to 9, thus characterized** that, for the purpose of compensation of wind loads, between the vertical walls of the base (6) and the supported object there are at least 3 pairs of mechanical or hydropneumatic springs (47) with a low spring rate mirror-image wise positioned around the supported object, with one pair for each axis of movement, one pair for the vertical axis and two pairs for the two horizontal axes, and towards the wall of the base they have mounted a sliding or a rolling gear (25), horizontally movable with one or several rolls on an extendable guidance system. (FIG.28, 29, 30)

17. Device according to claim 16, thus characterized that, to maintain equal distance of all the object's walls (22) to the walls of the base (20), through even a little movement of the spring, caused by a shift of the supported object relative to the base through a wind force, the spring force is automatically increased, governed by hydraulic control valves, until full extension into the required position is reestablished. And if during a movement of the spring caused by a wind force additionally there occurs an earthquake oscillation of the base, the reaction force against the wind force is only marginally increased because of the low spring rate, and consequently only a small differential force impacts the mass of the supported object as an acceleration force. (FIG.28, 29, 30)

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18. Device according to claims 16 and 17, thus characterized that the relative movement between the oscillating base (6) and the object, supported by Virtual Pendulums, which decouple the supported object from the oscillating base, is used to power one or several pumps (37) for auxiliary energy, which can be configured by themselves or in connection with centering and wind force compensating elements, that respond to the relative movement. (FIG.28, 30)

19. Device according to claims 2 to 9, thus characterized that a from the main building structure (51) separated part of the building (22), which is not exposed to any wind loads and which is also supported by Virtual Pendulums (56u), serves as a position reference for the position control of the main building exposed to wind loads. (FIG.31)

20. Device according to claims 2 to 9, thus characterized that the load support element between the load support point (P) of the Virtual Pendulum and the supported object (51) is designed as a vertical spring element with a very low spring rate and corresponding damping, whereby the spring elements can be mechanical, hydropneumatic or fluid elastic. (FIG.32)

21. Device according to claims 4, 6, 10 and 20, thus characterized that devices for wind load compensation (70) and vertical shock absorbtion (69) are integrated with a Virtual Pendulum (56) into one unit. (FIG.33, 56)

22. Device according to claim 4, thus characterized that the coupling element (8) of Virtual Pendulums on poles is supported by two hanging pendulums, supporting elements (2), and one standing pendulum, supporting element (7), and that the supporting elements (2) and (7) are spatially arranged at an angle away from the middle, to compensate the mast end's skewness during oscillation and to avoid that also the support point of the isolated object is subjected to the same skewness. (FIG.35, 35a, 35b)

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23. Device according to claims 4 and 6, thus charcterized that the coupling element (8, 9) has the load bearing support point (P) positioned at its underside and that it supports hanging objects and that the supporting elements (2, 11) are made of ropes. (FIG.37, 40, 41, 42)

24. Device according to claims 8 and 9, thus characterized that the supporting elements (2) are designed as ropes. (FIG.38, 39)

25. Device according to claims 4 and 23, thus characterized that the hanging pendulum, supporting element (2), hangs from the ceiling, which is connected to the base through the building, and that the unstable, standing pendulum, supporting element (7), at its lower end is supported by the center, that is formed by four or three slanted rods, ropes or chains (5), suspended from the ceiling. (FIG.42)

26. Device according to claims 4, 5, 7 and 23, thus characterized that at least three Virtual Pendulums support a mass as a oscillation reducer. (FIG.43, 44, 45, 46, 47, 48)

27. Device according to claims 4, 5, 6, 7, 8, 9, and 23, thus characterized that the stable hanging pendulums can be designed as ropes or chains. (FIG.36b, 37, 38, 39, 40, 41, 42, 45,46, 47, 48)

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28. Device according to claims 2 to 9, thus characterized that as its base to construct the Virtual Pendulums and to transfer the load of the supported object onto the ground a foundation (100) has at its underside towards the rims an inclined curvature. (FIG.49, 50)

29. Device according to claim 4, thus characterized that the coupling element (8) directly serves as a bearing for an object. (FIG.69)